0056

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX7241-Neural Networks and Fuzzy Logic**
Academic Year	: 2024/2025
Date	: 9th March 2026
Time	: 1330-1630hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Four (4)** questions in **four (4)** pages.
3. Answer **all questions.**
4. Answer for each question should commence from a new page. You will need **a graph paper** to draw diagrams for **Question 4.** Marks will be given for steps of calculation not only for the final answer. Therefore, all steps must be shown.
5. You may **use a calculator** for answering questions
6. This is a Closed Book Test **(CBT).**
7. Answers should be in clear handwriting and do not use red colour pens.

Question 1 (30 marks)

(a) What are the basic components of an Artificial Neural Network (ANN)? (5 marks)

(b) Discuss the role of activation functions in learning. (2 marks)

(c) Critically analyze the impact of activation function choice on network performance with examples. (4 marks)

(d) Assume the following parameters for a small ANN and answer the questions asked below.

- *Inputs to the ANN*: x_1=0.2, x_2=0.1
- *Hidden Layer*: 3 neurons
- The weights for the hidden layer neurons 1, 2, and 3, respectively are provided as:
  - Hidden layer node 1; w_{11}=0.4, w_{21}=0.1;
  - Hidden layer node 2; w_{12}=0.3, w_{22}=0.2, and
  - Hidden layer node 3; w_{13}=0.5, w_{23}=0.1
- Bias for each hidden neuron ($bias_h$) is 1.
- *Output Layer*: 1 output neuron
- The output weights from hidden neurons to the output neuron are assumed as:
  - w_{1O}=0.6 , w_{2O}=0.4, w_{3O}=0.7.
- The bias at the output layer ($bias_O$) is 1.
- *Desired Output*: $y_{expected}$=0.99
- *Learning Rate*: α=1
- *Activation Function*: Relu f(x) = max(0, x)

i) Use the Backpropagation training algorithm to find the error of the network after one forward traversal (show the calculations to 3 decimal points). (8 marks)

Use the Error formula given below to calculate the error.

$\delta_{hi} = (y_{expected} - y) \cdot f'(net_{hi})$ where $f'(net_{hi}) = 1$

ii) Calculate the new weights for hidden neurons in the first backward pass. (9 marks)

Use the equation for weight update $w_{ijnew}=w_{ijold}+\alpha \cdot \delta_{hi} x_j$

iii) What do you note about having the Relu function as the activation function ? (2 marks)

Question 2 (15 Marks)

(a) What is the advantage of using Colab instead of running a program in a PC with Anaconda? (2 marks)

(b) Which Python library is most popular for modeling structured data, such as data stored in Pandas DataFrames, and how is it referred to in sample code? (4 marks)

(c) First step in building an ANN model is to define what type of a model is it. What are the next 3 steps that you must follow to build the model? (3 marks)

(d) N is a rank 2 tensor with a shape of [3,3]. Reshape the N tensor to be of shape [1,9]. (2 marks)

$$N = \begin{pmatrix} 3 & 4 & 5 \\ 2 & 5 & 7 \\ 8 & 7 & 6 \end{pmatrix}$$

(e) Consider an image of 32 * 32. If stretched as a fully connected layer, calculate the number of weights associated with the layer. (2 marks)

(f) If 5 filters of the size of 5*5*3 are used, calculate the total number of weights. Use Bias value as 1. (2 marks)

Question 3 (25 Marks)

a) Let U = {1,2,3,4,5} be the domain where A and B are the fuzzy sets on U.

$$A = \left\{\frac{0.2}{1}, \frac{0.7}{2}, \frac{0.4}{3}, \frac{0}{4}, \frac{0.1}{5}\right\}, \quad B = \left\{\frac{0}{1}, \frac{0.9}{2}, \frac{0.8}{3}, \frac{0.3}{4}, \frac{0.5}{5}\right\}$$

What is A∩B and B/A ? (4 marks)

(b) What is a **fuzzy inference system (FIS)**? Name its main components. (6 marks)

(c) Compare Fuzzy Inference Systems **Mamdani FIS and Takagi-Sugeno** with respect to:

i. Output type
ii. Computational complexity
iii. Interpretability (6 marks)

(d) Consider a Sugeno fuzzy system with two inputs:

- CPU Load (x)
- Memory Usage (y)
- Output (z)

Rules:

R1: IF Load is High AND Memory is High THEN z = 0.7x + 0.3y + 10
R2: IF Load is Low AND Memory is High THEN z = 0.5x + 0.5y + 5

Given that CPU Load $x = 80(\%)$ and Memory Usage $y = 70(\%)$.

Fuzzy membership values for membership function μ are:

- μ(Load is High) = 0.8
- μ(Load is Low) = 0.2
- μ(Memory is High) = 0.7

i. Explain how the final output z is computed using the rules R1 and R2 and the value of z if the formula for calculation of Z is , $z = \frac{\mu_1 z_1 + \mu_2 z_2}{\mu_1 + \mu_2}$ (7 marks)

ii. State how rule weights influence the output (z). (2 marks)

Question 4 (30 Marks)

A smart vehicle is equipped with a fuzzy braking assistance system to support the driver during braking. Instead of applying a fixed braking force, the system uses fuzzy logic to determine the brake pressure based on driving conditions.

The goal is to ensure safe and smooth braking, especially under uncertain conditions such as varying road surfaces and driver behavior.

Inputs:

1. **Distance to Obstacle (D)** - The distance between the vehicle and the obstacle ahead.
2. **Vehicle Speed (S)** - Current speed of the vehicle.

Output:

- **Brake Pressure (BP)** - Amount of braking force applied.

In the design of a fuzzy-controlled traffic light system, the following fuzzy quantities and corresponding states were identified for *Input 1: Distance to Obstacle (D);*

- Very Close (VC), Close (C), Medium (M), Far (F), Very Far (VF)

The relationship between the two inputs (Distance to Obstacle and Vehicle Speed) and the output can be described with Fuzzy rules similar to the one given below.

- IF Distance is *Very Close* AND Speed is *Very Fast,* THEN Brake Pressure is *Very High*

(a) Identify the corresponding linguistic terms (5 values) for the other input variable and the output variable (3 values). (8 marks)

(b) Design **four** more fuzzy ***IF–THEN* rules** for the braking assistance system. (6 marks)

(c) Draw the membership functions for *Distance to Obstacle, Vehicle Speed*, and *Brake Pressure*. (select a membership function type that will help find the answers to the questions given below in Part (d).) (12 Marks)

(d) If the *Distance to Obstacle* is **1 meter** and the *Vehicle Speed* is **60 kmph**, compute the degree of membership for each fuzzy set in Distance to Obstacle and Vehicle Speed, using the membership functions selected in part (c). (4 Marks)